

Transitioning from open to robotic lung surgery

Brian E. Louie, Eric Vallières

Division of Thoracic Surgery, Swedish Cancer Institute and Medical Center, Seattle, WA, USA

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Correspondence to: Brian E. Louie, MD, MHA, MPH, FRCSC, FACS. Director, Thoracic Research and Education, Executive Co-Medical Director/ Surgical Chair—Swedish Digestive Health Institute, Director, Minimally Invasive Thoracic Surgery Program, Division of Thoracic Surgery, Swedish Medical Center, Suite 900, 1101 Madison Street, Seattle, WA 98104, USA. Email: brian.louie@swedish.org.

Abstract: Robotic lobectomy has grown considerably since its introduction over a decade ago. At its inception, a few surgeons took up the challenge of learning this new paradigm. In the subsequent years, new training pathways have been introduced along with simulation, mentorship, video review and telementoring. This has allowed open surgeons to transition to robotic lobectomy but little data exists to provide open surgeons an understanding of what occurs as ones adopts this technique. In this chapter, we will provide some personal perspective about our transition and then review the data around key issues for the predominantly open surgeon contemplating transitioning to robotic lung resection.

Keywords: Lung cancer; lung resection; robotics; thoracotomy; video-assisted thoracoscopic surgery (VATS); transition

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Introduction

The introduction of robotic thoracic surgery in the USA between 2006-2009 came at a time when adoption of video-assisted thoracoscopic surgery (VATS) for lobectomy appeared to have plateaued at about 30% of cases in the Society of Thoracic Surgeons database and 6% in the Nationwide Inpatient Sample (1,2). Surgeons who remained with open surgery cited concerns about safety, oncologic efficacy, the instability of the platform, visualization, limited instrumentation and difficulty with the learning curve. Robotics, through aggressive marketing, promised thoracic surgeons enhanced vision with 10x magnification, a stable platform through which to operate and enhanced dexterity with wristed instruments. The underlying goal was to increase the number of minimally invasive lung resections by transitioning open lobectomy surgeons who eschewed the VATS approach and unhappy VATS lobectomy surgeons to the robotic platform, understanding that to accomplish that goal, more open surgeons would have to transition than

VATS surgeons.

In the early days of robotic thoracic surgery, the task of transitioning regardless of prior experience seemed daunting. Outside of a couple of early adopters, little was known about how to transition (3-5). Would we open the fissure first? Would we try a fissure-less technique like our VATS colleagues or would robotics change our approach entirely? Now more than a decade later there is still very little known about transitioning to robotic lobectomy but there is more education and training for the surgeon wishing to transition. In this chapter, we will provide some personal perspective about our transition and then review the data around key issues for the predominantly open surgeon contemplating transitioning to robotic lung resection.

Personal perspectives

When the editors of this focused edition invited me to submit a paper on transitioning from open to robotic lobectomy, I had some reservations about being able to represent the experience of "open" surgeons. Despite spending part of my training with Dr. Kirby who authored the first randomized control trial of VATS vs. open lobectomy (6), I had not completed a single VATS lobectomy in training and had only first assisted on 4 as my attending surgeons took up the task of learning VATS lobectomy. In practice, I sought out the mentorship of my partner, Dr. Aye, to mentor me in VATS lobectomy after my first year in practice. For my second year in practice, I assisted Dr. Ave in his VATS lobectomy cases when I was able and he came to assist me on my cases. During a 2-year period, I was able to complete 25 lobectomies via VATS as the primary surgeon without Dr. Aye's assistance. I didn't think this qualified me as a master VATS surgeons given what we know about proficiency (7).

Admittedly, I was immediately attracted to the concept of robotics and heavily influenced by the marketing and promises of enhancements that were not backed by any data that I had been witness to. I went to "training" at Intuitive Surgical for a 1-day cadaver course with Dr. Eric Vallières, who did not perform VATS lobectomy but wanted to explore minimally invasive lobectomy. We worked on port placement and completed a lobectomy and thymectomy during that session. Upon return to Swedish Medical Center (Seattle, USA), we set up a proctor for our initial cases. I vividly remember the first case, a lobectomy. The Intuitive team and proctor arrived for the case. The case was proceeding slowly and safely with Dr. Vallières at the console and myself at the bedside, when the observing proctor was asked by the fellow how many lobectomies he had performed on the robot. He remarked that this was the first one he observed. The case was completed successfully and safely with the patient being discharged on postoperative day 3.

Even prior to this experience, we had planned to use a two-attending surgeon team for every robotic lobectomy until we were satisfied that the operation was being performed safely and with oncologic satisfaction. The first 30 robotic resections were done with this twoattending surgeon approach (8). We started with a threeport approach and an access port to allow for suctioning, retraction and extraction of nodes (8) and over time graduating to a completely portal 4 arm technique as advocated by Dr. Cerfolio (9). We also adopted Dr. Cerfolio's timed based limit to conversion if we failed to progress by the 4-hour mark shortly after publication but did not have to convert any cases. However, had we adopted this metric in the first 30 cases, it likely would have resulted in several conversions. Lower lobectomies were performed from an inferior approach, right upper lobes from anterior to posterior and left upper lobes from posterior then anterior as these were similar to our VATS approaches and adapted for the robot.

Trends in transitioning to robotic lobectomy

The adoption of robotic lobectomy has progressed much more rapidly than adoption of VATS lobectomy. In the last decade, several papers have documented the relative proportions of open, VATS and robotic lobectomy. In the State Inpatient Database (Arizona, California, Florida, New York, New Jersey, Maryland, Massachusetts and Washington) from 2008 to 2010, open anatomic resections decreased from 66% to 59% to 57%; whereas VATS increased from 34% to 40% and stayed 40%. During the same period robotics increased from 0.2% to 1.2% to 3.4% suggesting that some of the open surgeries had transitioned to robotics while VATS remained stable (10). In comparison, the STS national database which first coded for robotic lobectomy in 2009 reported that the number of robotic lobectomies in clinical stage I and II non-small cell lung cancer (NSCLC) rose from 5 to 436 and this represented 14% of all minimally invasive lobectomies for early stage NSCLC during the period 2009-13 (11). Similar trends during this time frame were also seen in the Nationwide Inpatient Sample (12).

Most recently, an analysis of the Premier Database of all lobectomies from 2011 to 2015 (13) showed an absolute decrease in open lobectomy of 11.5% and an increase in VATS lobectomy of 1.5% and in robotic lobectomy of 10.5%. Comparatively, an updated STS database analysis of early stage NSCLC [2009-2016] showed similar changes in all three types of lobectomy. At the end of the study period, robotic lobectomy accounted for 18%, VATS lobectomy for 54% and open lobectomy at 28% (14). It would seem that robotics is growing because of less open surgery as VATS lobectomy remains stable but it remains difficult to ascertain if the increase in robotics is solely due to open surgeons transitioning or it's a combination of VATS and open surgeons transitioning with some surgeons, perhaps graduating trainees, using the VATS approach. In either scenario, the goal of reducing open lobectomy for early stage NSCLC has been achieved.

Impact of transition

Established surgeons transitioning to a new surgical paradigm such as laparoscopy, VATS or endoscopic surgery, all share similar concerns during transition and its impact on the quality/safety of care, the learning curve and what will be the impact on operative time.

Impact on patient safety

Paramount during any transition to a new paradigm is the safety of the patient. Fortunately, the transition from open to robotic lobectomy has had limited impact on patient safety. Complication rates during one open surgeon's first 106 robotic lobectomies was 27% with no mortalities compared to 38% and 3% mortalities in a propensity matched group of open lobectomies (9). In another series of initial robotic lobectomies by a single open surgeon, overall morbidity rates were similar or lower than open lobectomy however, with each tertile, the rate of complication dropped from 33% to 22% to 6% suggesting that with more experience that safety improves (15).

Concerns for catastrophic events during robotic lobectomy are much higher than experienced. The most significant concern has always surrounded the risk of injuring the pulmonary artery. In these early series from open surgeons transitioning, injury to the pulmonary artery was documented just once. A recent multi-institutional series reported a 7.1% conversion rate and an intraoperative catastrophe rate of 1.9% which included the surgeon's learning curves (16). This rate is similar to catastrophic injuries during VATS lobectomy (17). It doesn't appear that the risk of injury is higher in the robotic learning curve defined as 20 cases or before. Most importantly, as we have gained more experience, a protocol for managing pulmonary artery bleeding has been described which may have lessened conversions to thoracotomy (18,19).

When safety was assessed during transition to robotic lobectomy using the STS database and the surgeons prior experience, open surgeons had better 30-day mortality compared to VATS surgeons transitioning to robotics and similar 30-day mortality to surgeons with no defined prior experience. Importantly, open surgeons achieved this early in their experience and were deemed proficient by 20 cases. Comparatively, major morbidity targets of 18% or less, were initially achieved by 67% of open surgeons transitioning and 100% achievement by 20 cases which was better than both VATS and *de novo* surgeons (14). This suggests that during transition from open to robotic surgery, patient safety is maintained and by 20 cases open surgeons can be proficient.

Impact on learning curve and operative times

The learning curve for robotic lobectomy is tied to operative time as the underlying metric. Using an operative time defined as incision to closure and including time for wedge resection and frozen section analysis, Veronesi et al. (20) showed that operative times plateaued at 18-20 cases with no further improvement. Similar results using a hybrid robotic technique were demonstrated by Meyer et al. (21). However, a recent analysis of the STS database showed that open surgeons transitioning to robotic lobectomy were least likely to achieve initial proficiency compared to surgeons transitioning from VATS or de novo. At the 20th case mark, only 29% of open to robotic surgeons were proficient (defined as operative time <250 minutes). At the 50th case mark, 57% of open surgeons were proficient (14). This suggests that open surgeons, while performing robotic lobectomy safely, will need closer to 50 cases to become proficient.

Training and mentorship

For the average thoracic surgeon who wishes to transition from open to robotic lobectomy, the necessity of needing 50 cases to become proficient is a long reach. Consider that data from the University Health System Consortium and the Association of American Medical Colleges Faculty Practice Solution Center database estimates that general thoracic surgeons average 51 anatomic pulmonary resections per year of which 16 were minimally invasive (22). Outside of a handful of very busy surgeons, a case load of 50 lobectomies per year is likely on the higher end of the volume spectrum. Not all of these cases will be suitable for robotics during transition so it may take a year or more to accumulate the necessary cases to become proficient and longer in lower volume centers.

Training and mentorship will be keys to facilitate this transition to robotic lobectomy. Currently, there are two primary training pathways. Surgeons in practice can participate in a basic thoracic training course with didactics and hands on time followed by proctored cases. After this, surgeons participate in an advanced training course with additional didactics and hands on time followed by selective mentorship via the web or in person. Surgeons in training have the opportunity to apply for the American Association

Page 4 of 6

of Thoracic Surgery Graham Robotics Fellowship which is an intensive 2-day didactic and hands on course followed by graduated training with the preceptor at their institution of training. Candidates who meet a minimum case threshold then return for advanced hands on training.

While such training can reduce the learning time by arming the new robotic surgeon with port placement, the most efficient steps for performing a certain lobectomy, and team techniques for docking, the surgeon must still master the ability to control the instruments so that inadvertent injury is avoided, to handle tissue delicately without the haptic feedback so that tissue trauma is minimized and to orchestrate the multitude of hand, finger and feet motions that control the robotic movements. Mastery of these orchestrated events takes time if the surgeon is only on the console 1-2 time per month. Simulation is one highly recommended option for the transitioning surgeon to continue practicing skills and orchestrated moves (23). Simulation has improved considerably with the addition of multiple companies and virtual reality type programs. This is likely to have a profound impact on the surgeon-robotic interaction going forward (24).

In addition to training and simulation, I have found that mentorships/coaching to be particularly helpful in progressively becoming more efficient with my movements. There are many mentorship type tools available for robotic surgeons. First, in person trips either to visit a colleague who has developed a certain mastery or to have the same colleague visit you in your organization and coach you through your cases. These one-on-one interactions can be invaluable in pushing through to another level. Second, using video review of cases has helped us educate our trainees but such review as a transitioning surgeon is also helpful. C-SATS (www.csats. com, accessed Jan 9, 2019) is an online video review company that seeks to improve skills via intraoperative video review. Each raw unedited video is processed and then reviewed by experts in the field. Feedback on the major steps of an operation is provided with suggestions for improvement as well as links to videos thought to represent the best in class that the surgeon can review. Lastly, also available is tele-mentoring that is conducted during an operation. A telementor has a direct view of the operating surgeon's field of view and can provide voice input but also telestrations directly on to the surgeon's screen.

The non-adopter

Despite the various training pathways and the variety of

mentorship options, some surgeons will not transition nor adopt robotics. It seems like "everyone" is transitioning to robotics but as of 2016, only 210 (25%) out of 844 surgeons in the General Thoracic Surgery STS database had performed at least one robotic lobectomy. And, of those, 145 had performed less than 20 robotic lobectomies (14). So, why might a surgeon not transition to robotics? Unfortunately, there is no data but based on the current experience, several factors may play a role in that decision. First, today's open thoracotomy is not the same as the thoracotomy of 20 years ago. The incision is smaller, multimodal pain control is better, protection of the intercostal nerve can be accomplished and length of stay is only a day longer (25). Second, it appears for the average thoracic surgeon, a commitment to transitioning to robotics is a must given that proficiency is close to 50 lobectomies. This translates into 2-year transition period that warrants not only training but mentoring until one is comfortable. Third, the issue of operative time and cost concerns remain valid in the era of cost constraint for which robotics is heavily dependent upon a shorter operative time to balance out the cost equation (25,26). Lastly, surgeon comfort with the operation plays a role. As Dr. Vallières has verbalized for some time, when he factors in the above issues, they are not enough reasons for him to want to leave his comfort zone for the promise of robotic surgery, though he is comfortable with a multiport VATS approach.

Conclusions

Robotic lobectomy is increasing as a portion of all lobectomies performed for early stage non-small cell carcinoma. Transitioning as a prior open surgeon is becoming much easier with new training pathways. However, it requires a commitment from the surgeon to embrace the multitude of educational platforms and mentorship. During transition patient safety and quality can be maintained even in one's early cases. Proficiency, however, takes about 50 cases using operative time as a metric.

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Footnote

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Video-Assisted Thoracic Surgery, 2020

Page 6 of 6

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